A NEW FORM OF STIMULI FOR LIFTED WEIGHT EXPERIMENTS

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The questions regarding the form and material of the stimuli to be used in lifted weight experiments have been variously answered by different experiments. Fechner [1] placed his weights in holders which were grasped and lifted with the palm of the hand upward. Galton [2] used simple shotgun shells loaded to the proper intensity with successive layers of shot, cotton wool and wads. These weights were grasped by the subject " between his finger and thumb, the finger pressing against the top, the thumb against the bottom of the cartridge." There is a set of brass weights loaded with paraffin made in this form by the Cambridge Scientific Instrument Company, Ltd. Sanford [3] suggested the use of envelopes weighted with sheet lead, to be lifted vertically suspended between the thumb and forefinger. Presumably weights of this type were intended only for use in an elementary laboratory course. Fullerton and Cattell [4] employed flat wooden boxes weighted with shot and cotton, which were lightly grasped on the side with the thumb and fingers. Urban [5] used weights of the same general form made of hollow brass cylinders loaded with shot and paraffin, which were also lightly grasped on the side between the thumb and fingers. Inasmuch as paraffin is not entirely anhygroscopic, solder was substituted in a second set of weights exactly similar in form and size to those used by Urban.[6] A set of weights made of hard rubber and weighted with shot, advertised in 1894 by the Garden City Model Works, is

[1] G. T. Fechner. *Elemente der Psychophysik.* 2nd Ed., 1889, I., 97f.
[2] F. Galton. *Inquiries into Human Faculty and Its Development.* N. Y., 1883, 34ff, 370ff.
[3] E. C. Sanford. *A Course in Experimental Psychology.* Boston, 1898, 413.
[4] G. S. Fullerton & J. McK. Cattell. *On the Perception of Small Differences.* Phila., 1892, 118f.
[5] F. M. Urban. *The Application of Statistical Methods to the Problems of Psychophysics,* Phila., 1908 1ff.
[6] S. W. Fernberger. On the Elimination of the Two Extreme Intensities of the Comparison Stimuli in the Method of Constant Stimuli. *Psychol. Rev.,* XXI., 1914, 337f.

mentioned by Titchener.[7] They consisted of 9 cylinders, 1½ inches in diameter and 4 inches high.

It seems curious that experimenters have overlooked the obvious fact that the size and form of the stimuli employed in this sort of experimentation may have an effect upon the measures of sensitivity. Experimenters have directly compared the results for lifting weights by the Fechner handles with the results for lifting by grasping the weight itself. It seems obvious that the manner of lifting a weight must affect the results. The processes underlying the formation of judgments in lifted weight experiments are exceedingly complex and involve pressure, muscular, articular and tendinous sensations with widely different points of origin,[8] which might be expected to differ with the various forms of weights and the manner of lifting them. In the face of ignorance the safe course is to use a single standard form. Weights of the size and form suggested by Urban have had a large and satisfactory usage in the hands of a number of recent investigators. They are comfortably grasped between the thumb and forefingers.

The materials of which the weights are composed also require standardization. In the first place the physical weight must be kept constant within the limits of error of the experiment. Urban[9] found that the wooden weights of Fullerton and Cattell varied, with differences in atmospheric temperature and moisture, sometimes more than 15 mg. The brass weights constructed by Urban and the writer overcome this difficulty. Such a set, loaded with solder, in use in the Clark Psychological Laboratory for the past eight years, has not shown for any single weight as much as 10 mg. variation.

Ide[10] has recently found that warm or cold stimuli are overestimated when compared with stimuli which do not arouse temperature sensations. Ide compared cold stimuli of 46° F and warm stimuli of 147° F. with neutral stimuli of 70° F. The resulting variations in the points of subjective equality for the method of constant stimuli are considerable; in some cases the difference is more than three grams.

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[7] E. B. Titchener. *Experimental Psychology.* N. Y., 1905, II., Part 2., 265.

[8] cf. S. W. Fernberger. An Introspective Analysis of the Process of Comparing. *Psychol. Mono.,* XXVI (Whole No. 117), 1919.

[9] Urban. *op. cit.,* 2f.

[10] A. L. Ide. *The Influence of Temperature on the Formation of Judgments in Lifted Weight Experiments.* Univ. of Pennsylvania Thesis, Phila., 1919, Pp. 25

Ide has investigated this problem systematically but the general observation appeared in the literature many years ago. In 1846, E. H. Weber [11] observed that a cold coin at —4° to 7° C. placed on the forehead seemed as heavy as two superinposed coins of the same size but of a temperature of 37° to 38° C. Some years later Szabadföldi [12] repeated this experiment but extended the range of warm temperatures beyond that employed by Weber. Szabadföldi found that both very cold and very warm stimuli are overestimated when compared with neutral stimuli which do not arouse temperature sensations. These results are entirely in accord with Ide's findings although in one case the experimenters were dealing with passive pressure and in the other case with active lifting.

In some recent experiments performed by the writer during the winter, the subjects sometimes complained that the brass weights felt cold. Metal readily gives rise to thermal sensations because of its high thermal conductivity. For this reason we have constructed a set of weights from hard rubber which has a low coefficient of conductivity, and which further recommends itself as anhygroscopic, durable and easily worked.

The coefficient of thermal conductivity (calories per cm. per sec. per degree) for yellow brass is about 0.20 and for vulcanite about 0.002.[13] In terms of stimulus and of sensation, if thermal conductivity were the only factor, this difference would mean that the range of temperatures which do not arouse temperature sensations would be 100 times as great for hard rubber as for brass.

Hard rubber seems to have been little used for lifted weights. We noted above one set of rubber weights. The Fechner weight holders listed by Spindler and Hoyer of Göttingen in their catalogue of 1910 have hard rubber handles. But neither of these forms of weights have been used in important experimental work. On the other hand, it has been almost universally recognized in aesthesiometric work that metal points arouse temperature as well as pressure sensations

[11] E. H. Weber. *Der Tastsinn und das Gemeingfühl.* 1846 and also Tastsinn in Wagner's *Handwörterbuch d. Physiol.,* Braunschweig, 1846, III., Part 2.

[12] M. Szabadföldi. Zur Physiologie des Tastsinns. *Unters. z. Naturlehre d. Menschen.* IX., 1865. For an account of these experiments *cf.* O. Funke. Der Tastsinn und die Gemeingefühl in Hermann's *Handbuch d. Physiol.,* Leipzig, 1879, III, Part 2, 320f. and also G. T. Ladd. *Elements of Physiological Psychology,* N. Y., 1887, 347f.

[13] *Cf.* A. Winkelmann. *Handbuch der Physik,* Leipzig, 1906. III, Part 1, 489 & 505.

and that they are therefore to be avoided. Titchener,[14] for example, remarks in discussing the Griesbach aesthesiometer, —"The points are of metal. This is a disadvantage as it introduces the temperature error."

It is difficult to discover in the literature the origin of the use of non-metallic materials to eliminate thermal sensations. Hall and Donaldson[15] in 1885, in discussing the influence of temperature in the perception of movement on the skin, say: —"It was soon found, however, that these limits overlapped, *i. e.* that an intermediate temperature of a metallic point could be so chosen that it would stimulate both heat and cold spots. We therefore had recourse to non-conducting cork points of such shape that the smooth and rounded edge of a right-angled triangle was applied to the skin transversely to the direction of motion. Thus the sensations of temperature appeared to be entirely eliminated." In 1887, Hall and Motora[16] quite casually speak of the use of hard rubber for the same purpose. In the manufacture of aesthesiometers, bone and ivory have also been employed as non-conducting materials to eliminate temperature sensations.[17]

The new set of weights in the Clark Laboratory conform to all the requirements which we have noted. They are hard rubber cylinders, 2½ inches in diameter and 1 inch high. Hard rubber can be purchased in round bars, just 2½ inches in diameter. The cylinders are cut off and hollowed out at one end to a depth of ½ inch; a wall at the sides ⅓ inch in thickness is left. A round brass plate, ⅛ inch in thickness, is inserted into this cavity and is held in position by two bolts and nuts which pass through holes bored in the top of the weight and in the brass plate. The heads of the bolts are counter-sunk into the top of the weight so that they are below the surface. A small number is stamped with a steel die on each weight for purposes of identification.

When the weights are calibrated, the brass plate is unscrewed and solder is melted on it until the rubber shell, the brass plate, the nuts, the bolts and the solder weigh just a little more than the desired amount. Some of the solder is then carefully scraped away until the desired weight is obtained.

[14] E. B. Titchener. *Experimental Psychology.* N. Y., 1901, I., Part 1., 382.

[15] G. S. Hall & H. H. Donaldson. Motor Sensations on the Skin. *Mind.* O. S. X., 1885, 568.

[16] G. S. Hall & Y. Motora. Dermal Sensitiveness to Gradual Pressure Changes. *Amer. Jour. of Psychol.,* I., 1887, 74.

[17] *Cf.* A. Gemelli. Un nuovo estesiometro. *Atti. d Soc. Ital. d. Sci. Nat.,* LII., 1913, 193-200.

This present set of weights has been tested a number of times during a period of two weeks in which there have been great variations in temperature and humidity. In no case did any weight vary as much as 5 mg., a variation which is far within the limits of accuracy required in the lifted weight experiment.

Under experimental conditions these weights actually do not arouse temperature sensations. Even when placed for several hours on a very hot radiator or outdoors in air at 20 F., several subjects found that the hard rubber weights were only slightly cool and warm, whereas the brass weights were almost painfully cold and painfully hot. Presumably even unusual changes of room-temperature with the hard rubber weights will not arouse sensations of warmth or cold at all.